

# Unit 8 Topic 7: Equilibrium

## CDO IB Chemistry SL

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### Assessment Statements

#### 7.1 Dynamic Equilibrium

7.1.1 Outline the characteristics of chemical and physical systems in a state of equilibrium

#### 7.2 The position of Equilibrium

7.2.1 Deduce the equilibrium constant expression ( $K_c$ ) from the equations of homogeneous equilibrium

7.2.2 Deduce the extent of a reaction from the magnitude of the equilibrium constant  $K_c$

7.2.3 Apply Le Chatelier's principle to predict the qualitative effects of changes of temperature, pressure and concentration of the position of equilibrium and on the value of the equilibrium constant

7.2.3 State and explain the effect of a catalyst on an equilibrium reaction

7.2.4 Apply the concepts of kinetics and equilibrium to industrial processes

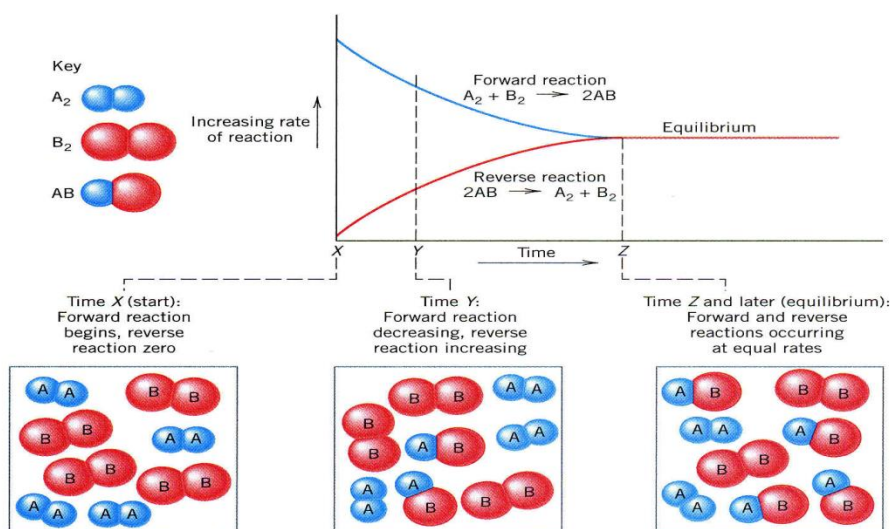
## Reactions at equilibrium

- Reversible reactions –
- These types of reactions reach an equilibrium –

## Dynamic nature of equilibrium

- The point of equilibrium in a reversible process
- The concentration of the reactants and products

## Dynamic nature of equilibrium



**Figure 14-12 A<sub>2</sub>, B<sub>2</sub>, AB Equilibrium** Equilibrium is achieved when the rates of the forward and reverse reactions are equal.

## Writing Equilibrium Reactions Expressions

- Reactions at equilibrium are written
- $K_c$  is the equilibrium constant
- *Example*

## Equilibrium constants

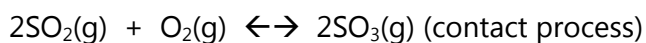
- The significance of the Law of Mass Action is that even with a variety of initial

### What the Size of $K_c$ tell us

- $K_c$  tells us about the point of equilibrium as well
  - $K_c \gg 1$
  - $K_c > 1$
  - $K_c = 1$
  - $K_c < 1$

### Example : Writing $K_c$

- Write the  $K_c$  expressions for the following reactions



### Le Châtelier's Principle

- When stress is applied to a system at equilibrium,
- Changes that affect the point of equilibrium
  - Concentration of
  - Pressure in a

- How stresses change Equilibrium

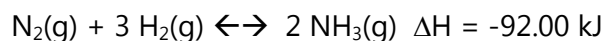
Stress	Effect On Equilibrium	Why This Occurs

- How stresses change Equilibrium – Temperature

Stress	Effect On Equilibrium	Why this Occurs

- Example : Le Chatelier's Principle

For the following reaction, predict the direction the reaction will shift if the equilibrium is disturbed by:



- Adding  $\text{N}_2$
- Adding  $\text{NH}_3$
- Increasing Pressure
- Increasing Temperature

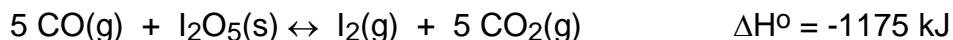
1. Write the following equilibrium expressions for each of the following reactions:

- a.  $\text{O}_3(\text{g}) + \text{NO}(\text{g}) \rightleftharpoons \text{O}_2(\text{g}) + \text{NO}_2(\text{g})$
- b.  $2\text{CO}(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{CO}_2(\text{g})$
- c.  $\text{NH}_4\text{NO}_3(\text{s}) \rightleftharpoons \text{N}_2\text{O}(\text{g}) + 2\text{H}_2\text{O}(\text{l})$
- d.  $2\text{H}_2\text{O}(\text{g}) \rightleftharpoons 2\text{H}_2(\text{g}) + \text{O}_2(\text{g})$

2. For each of the following reactions write the equilibrium expression and determine the equilibrium position

- a.  $\text{N}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{NO}(\text{g})$   $K_c = 1 \times 10^{-30}$
- b.  $\text{N}_2\text{O}_4(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g})$   $K_c = 0.212$
- c.  $2\text{NOBr}(\text{g}) \rightleftharpoons 2\text{NO}(\text{g}) + \text{Br}_2(\text{g})$   $K_c = 0.014$
- d.  $\text{Br}_2(\text{g}) + \text{Cl}_2(\text{g}) \rightleftharpoons 2\text{BrCl}(\text{g})$   $K_c = 7.2$
- e.  $\text{C}_3\text{H}_8(\text{g}) + 7/2 \text{O}_2(\text{g}) \rightleftharpoons 3\text{CO}_2(\text{g}) + 4\text{H}_2\text{O}(\text{g})$   $K_c = 1 \times 10^{81}$

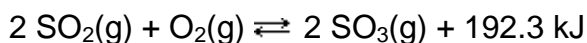
1. For the following reaction



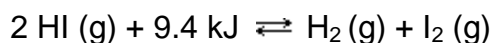
for each change listed, predict the equilibrium shift and the effect on the indicated quantity.

	Change	Direction of Shift ( $\rightarrow$ ; $\leftarrow$ ; or <i>no change</i> )	Effect on Quantity	Effect (increase, decrease, or <i>no change</i> )
(a)	decrease in volume		Amount of $\text{I}_2$	
(b)	raise temperature		amount of $\text{CO(g)}$	
(c)	addition of $\text{I}_2\text{O}_5\text{(s)}$		amount of $\text{CO(g)}$	
(d)	addition of $\text{CO}_2\text{(g)}$		amount of $\text{I}_2\text{O}_5\text{(s)}$	
(e)	removal of $\text{I}_2\text{(g)}$		amount of $\text{CO}_2\text{(g)}$	

2. Suggest four ways to increase the concentration of  $\text{SO}_3$  in the following equilibrium reaction. Be specific.



3. Use Le Chatelier's Principle to predict how the changes listed will affect the following equilibrium reaction:



- Will the concentration of HI increase, decrease, or remain the same if more  $\text{H}_2$  is added?
- What is the effect on the concentration of HI if the pressure of the system is increased?
- What is the effect on the concentration of HI if the temperature of the system is increased?
- What is the effect on the concentration of HI if a catalyst is added to the system?